KIWO® INFO

And the Compromise between Resistance and Resolution

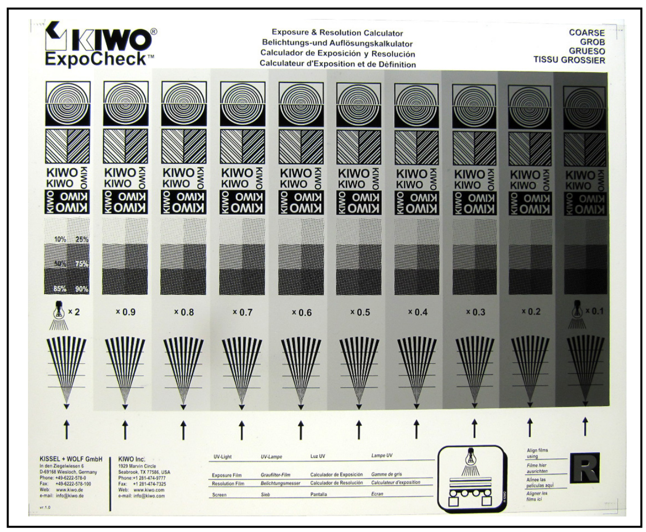
Proper stencil exposure can be described as the point at which the emulsion reaches a synergistic balance between resistance and resolution. Proper exposure is dynamic in nature, as it fluctuates with printing requirements and the quality and consistency not only of the artwork and the screen, but also of the equipment used to generate the art and the screen. Environmental conditions constitute another dynamic force in play. Understanding how each of these variables impact proper exposure, helps us establish mechanisms for controlling them. Likewise, this improves our ability to tighten production parameters, which leads to higher quality and more consistent product reliability.

Since proper exposure is predicated on dynamic variables, it stands to reason frequent exposure calibrations are required to maintain exposure control and to assure quality control. They should be done for each mesh count and whenever changing mesh, emulsion, coating technique, exposure lamps and distance.

Moreover, proper exposure plays an important role in one's ability to print with challenging media, such as aggressive printable adhesives and solvent-based inks, abrasive ceramic and glass frit inks, as well as water-based and discharge inks. This report will look at the best way to determine proper exposure and some pitfalls to avoid when doing so.

Determining proper exposure involves evaluating stencils created using a series of varying exposure times, which allows us to determine the best balance between its hardness or durability and its copying properties (resolution, mesh bridging and edge definition). Using commercially available exposure calculators is the easiest way to do this. Recalibrate exposure times whenever changing mesh, emulsion, stencil thickness, exposure lamps and distance.

Exposure calculators consist of two primary components, a resolution film and an exposure test film. The resolution film incorporates common test pattern images comprised of concentric circles, horizontal and vertical lines, halftones and text. This pattern is stepped or repeated up to ten times so objective observation can be made between the series of exposures. The beauty of the calculator is you do not need to make a series of exposures; instead you make only one very long exposure and the calculator takes care of the rest. Each repeated pattern is referred to as an exposure step. Overlaying each exposure step is the exposure test film comprised of a series of filters progressing in density, as seen in the following image. These filters effectively provide us with our series of exposures.



Determining the exposure time to use for the test exposure is key to using exposure calculators correctly. Use a *test* exposure time equal to two times the *expected* exposure. Expected exposure could be: the exposure times currently used, an estimate of the anticipated exposure based on experience, or exposure data obtained from the emulsion manufacturer.

Why do I need to double the expected exposure time? Several exposure steps ranging from

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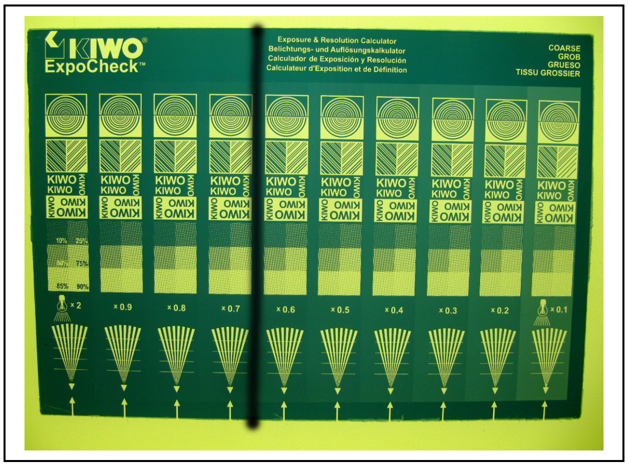
under to overexposure are needed to properly identify the step where no visible color variation is seen between adjoining steps or between adjacent filtered and unfiltered portions of the calculator. In other words, which step shows no visible appearance of the rectangular filter covering the emulsion? The following picture of an exposure test shows a black line at this point. All exposure steps left of the black line show no color variation between the facing arrows along the bottom of the stencil, while exposure steps right of the line do.

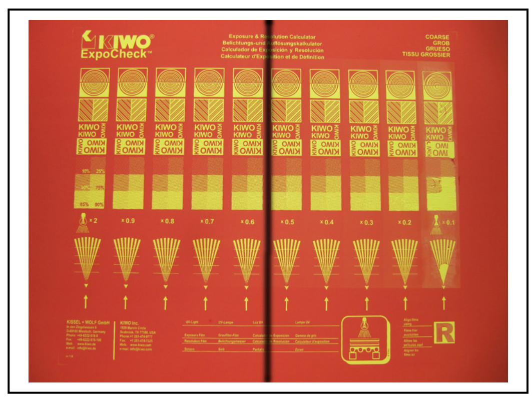


Therefore, the first exposure step left of the black line is considered to have received enough UV to provide very good chemical and mechanical resistance. This completes step one of the two-step process of determining proper stencil exposure.

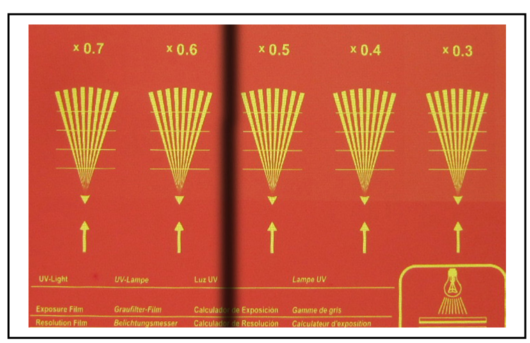
Before we move on to step two, I would like to address a common belief in the industry as it relates to using color change as a way of determining proper exposure.

A common misconception is that color variation, or the point of "no color change", can only be used to gauge expose times of diazo sensitized emulsions, but not pre-sensitized SBQ emulsions a.k.a. "pure photopolymers". This originates from the fact diazo sensitized emulsions consist of two colors, yellow (the color of diazo) and whatever pigment (blue, red, violet, etc.) is used to color the emulsion. As these emulsions cure, the yellow cast from the diazo wanes the closer they get to full exposure, thus the color change.

Although I confess SBQ emulsions are more difficult to gauge, especially on fine meshes, because they are comprised of only one color, and technically speaking I suppose there cannot be a "color" change if only one color is present, but I still contend there is a color shift attributed to density. This is illustrated in the following picture of a red pigmented SBQ emulsion. Notice the changes from step to step as viewed from right to left. Then about midway you no longer see any changes between the steps. The color changes because emulsion washes away from the squeegee side of the screen when developing the under exposed steps leaving a thin, lighter colored stencil. When the color stops changing you know the emulsion is adequately cured because no emulsion washes away. Properly cured emulsion solves common stencil related problems like excessive pinholes, stencil breakdown, reclaiming difficulties and emulsion stains.



Each step has an associated number (as seen in the image below) that is used as the multiplier for calculating the representative exposure for that step. This number is multiplied by the time used to expose the calculator.



For example, if 60 seconds represents the time used to expose the calculator and 0.6 represents the point of no color change, then 36 seconds (60x0.6) represents the exposure time of that step. 0.6 indicates the percentage (60%) of light transmission at that exposure step, or the inverse of the neutral density filter. The result is the recommended exposure time to properly harden the emulsion and achieve very good resistance.

Identifying where no color change occurs can be done immediately after developing the screen while it is wet or after the screen dries. More steps of visible color change occur when evaluating a damp screen, thus reflecting a longer exposure time, and fewer steps of visible color change occur when viewing a dry screen.

Why is there a difference between a wet screen and a dry screen? A wet screen is slightly swollen from absorbing water, which makes observing slight color variations easier.

Which method should I use? Debates reign. Arguments can be made supporting both methods. The size of the job and/or how detailed the artwork is may help determine the method to use, however, the type of ink required for the job is the clear determining factor for me. When the job calls for characteristically challenging or aggressive inks, I use a wet screen to select and calculate exposures. Textile printers using water-based and discharge inks, for example, should choose their exposure times from a wet screen to enhance screen longevity. Longer exposure times offer extra insurance especially for long runs.

Far too often printers err on the side of shorter exposures instead of erring on the side of longer exposures, and it is not always because they are pressed for time. Often times it is attributed to one or more of the following:

- Film positives lack density (poor D-max)
- Using inappropriate mesh count for the detail involved
- Using stencils that are too thick
- Printing halftones or process color from linearly output film
- Using exposure units with poor vacuum drawdown
- Starting exposure before adequate vacuum is reached
- Using poorly designed exposure systems

Get these variables under control and you will be amazed by the amount of processing latitude you have and how forgiving the process becomes.

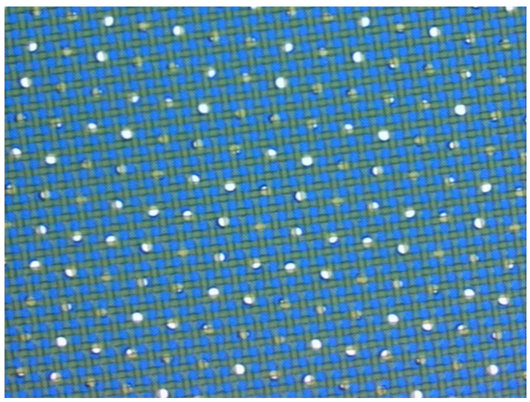
As mentioned earlier, determining the point of no color change is just the first step of a two-step process for calibrating proper expose.

Step two is determining whether the stencils copying properties (resolution, mesh bridging, and edge definition) meet or exceed production requirements. Make sure to evaluate the appropriate exposure step selecting in step one.

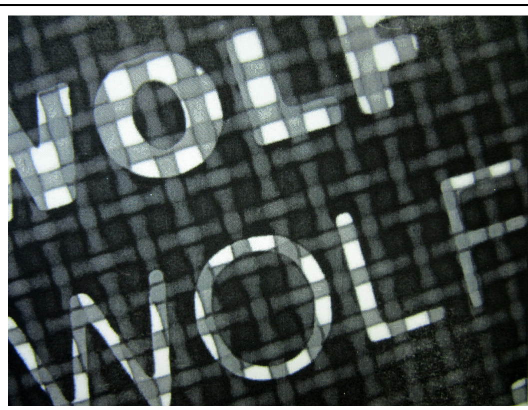
A common mistake made in evaluating copying properties, especially resolution, is making an assessment based on whether or not the finest details of the exposure calculator are open. Use this as a gauge only if production art details are as fine. Do not sacrifice the stencils durability by selecting a step with a shorter exposure time in order to capture details you will not print in production.

Another common mistake is trying to capture details that are not even printable. Much of the halftone artwork I see today contains some highlight and shadow dots that are too small to be printed successfully. This is not to say I cannot resolve most of them in the screen, as often times i can, but they will not print properly, if at all. Unknowingly, but innocently, the screen department adjusts exposure times lower in an effort to open up every highlight dot on the film positive. This is one of the root causes why the vast majority of screen printers under expose screens, then suffer from the consequences.

Take for example the following stenciled image of fine highlight dots. The emulsion *did* resolve the dots but it doesn't look like it because the dots are too small to print properly, meaning over half of the dots are fully or partially blocked by the threads. Only the dots positioned directly over the mesh openings will print. This is a leading cause of regional moiré in highlight areas of the print.



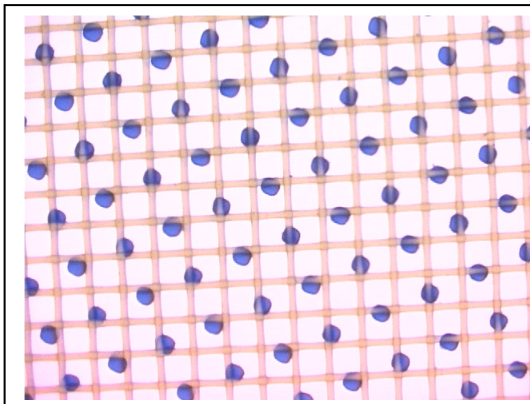
Another example below shows poor art-to-mesh relationship as it relates to text. In this example you see the letter F – although fully resolved by the emulsion – falls directly on a thread, while the letter L luckily falls in between the threads. This case illustrates how choosing the wrong mesh count also causes problems. The mesh count here is a 156-64, which clearly is unable to support this fine detail. This artwork requires a much finer mesh count.



It is in situations like these we've just looked at that throws off the synergistic balance between stencil durability and resolution. It becomes wrongly skewed towards the resolution side unjustly sacrificing durability. What can we do to circumvent this from happening?

To help avoid falling into the trap of under exposing screens and suffering from printing inconsistencies, control the artwork so the finest detail width is equal the width of at least two mesh openings plus one thread, or twice the screen (mesh + emulsion) thickness. Of course this is not always possible but the closer you adhere to this rule, the less likely you will be to encounter inexplicable printing problems often caused by underexposed screens, and the simpler the printing process will be.

Now take a look at another example this time looking at shadow dots. Again, the emulsion resolved the dots however, because the dots are so small, the print from this stencil will result in solid 100% coverage as a result of dot gain once the ink levels out leaving no shadow detail.



Understanding the art-to-mesh relationship and how it impacts not only your printing but also your process, helps you make more informed decisions as they relate to artwork limitations, mesh selection, and screen making.

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